

Diverging Diamond Interchange 101

14th Annual ACEC-KY FHWA KYTC Partnering Conference

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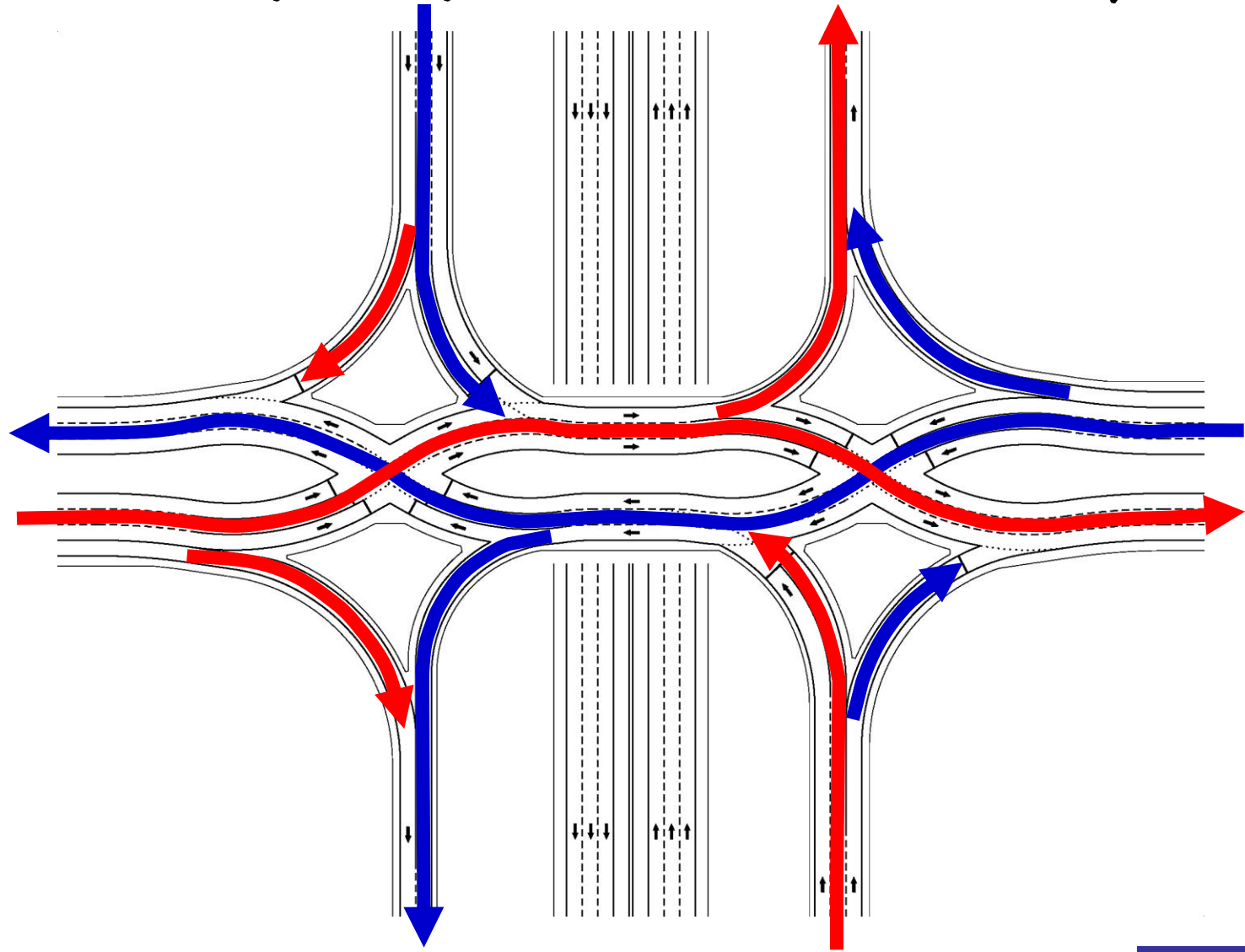


Presented By:
Scott Wolf, PE, PLS

What is a Diverging Diamond Interchange (DDI)?

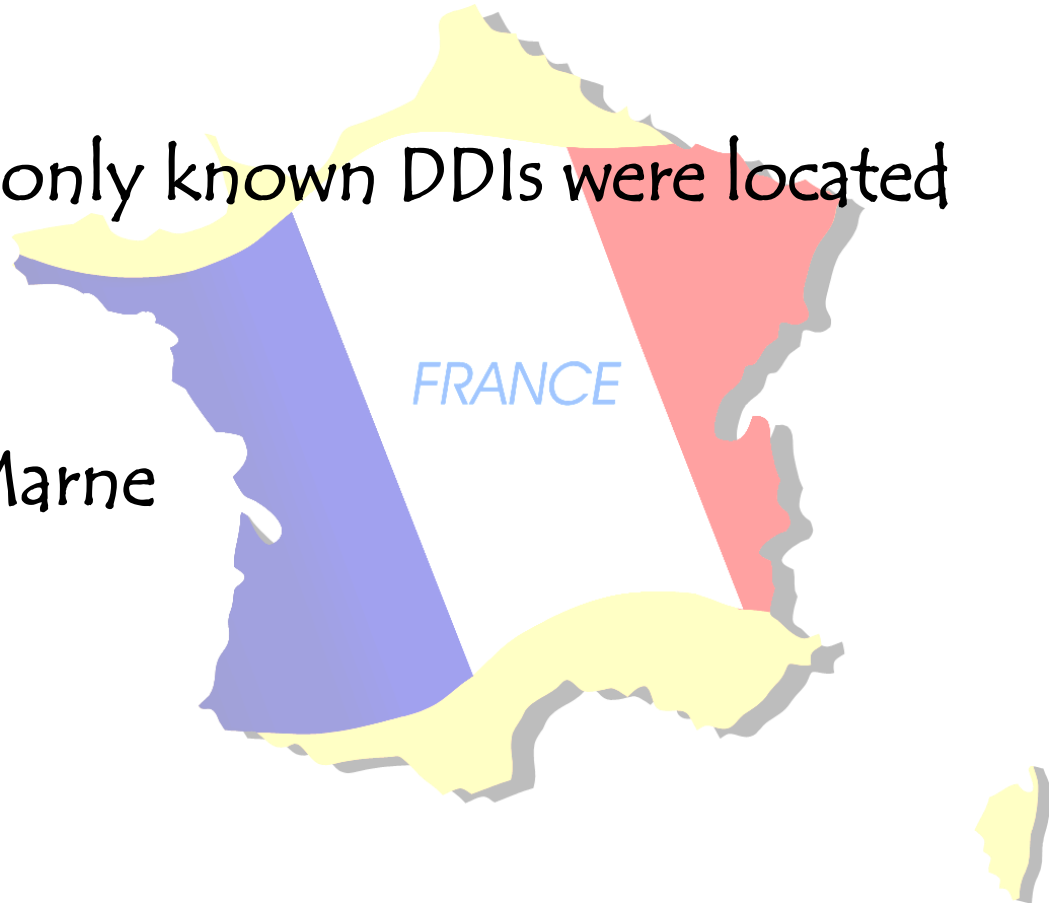
- ♦ It's a non-traditional design to accommodate left-turning movements at signalized, grade separated interchanges while eliminating the need for left-turn phasing of the traffic signals
- ♦ Also known as a Double Crossover Diamond (DCD)

What is a DDI? (Continued)



Where did the DDI come from?

- ◇ The DDI originated in France in the 1970's
- ◇ Until recently, the only known DDIs were located in France:
 - Versailles
 - Le Perreux sur Marne
 - Seclin



A13 & RD182 Versailles, France



Only 11 light injury crashes reported in 5 years compared to an average of 23 fatal/injury crashes of a typical DI in the USA

D45 & A4

Le Perreux sur Marne, France

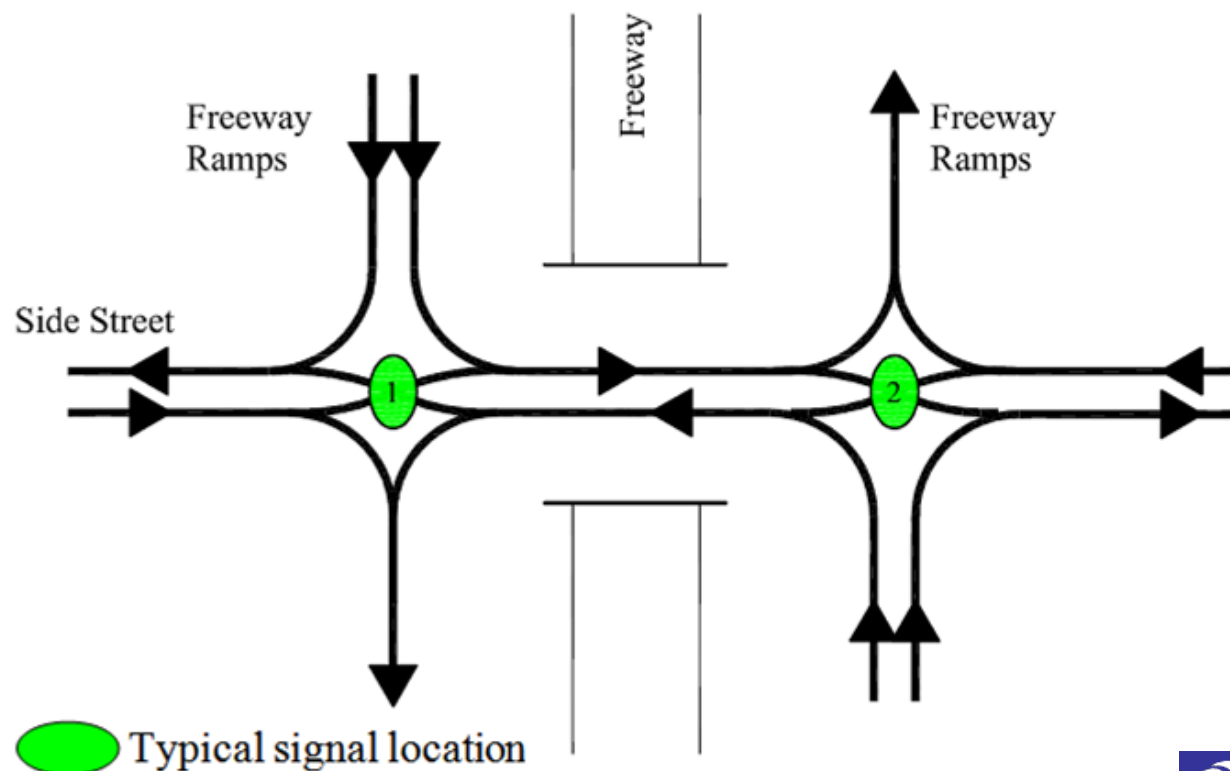


A1 & D549 Seclin, France

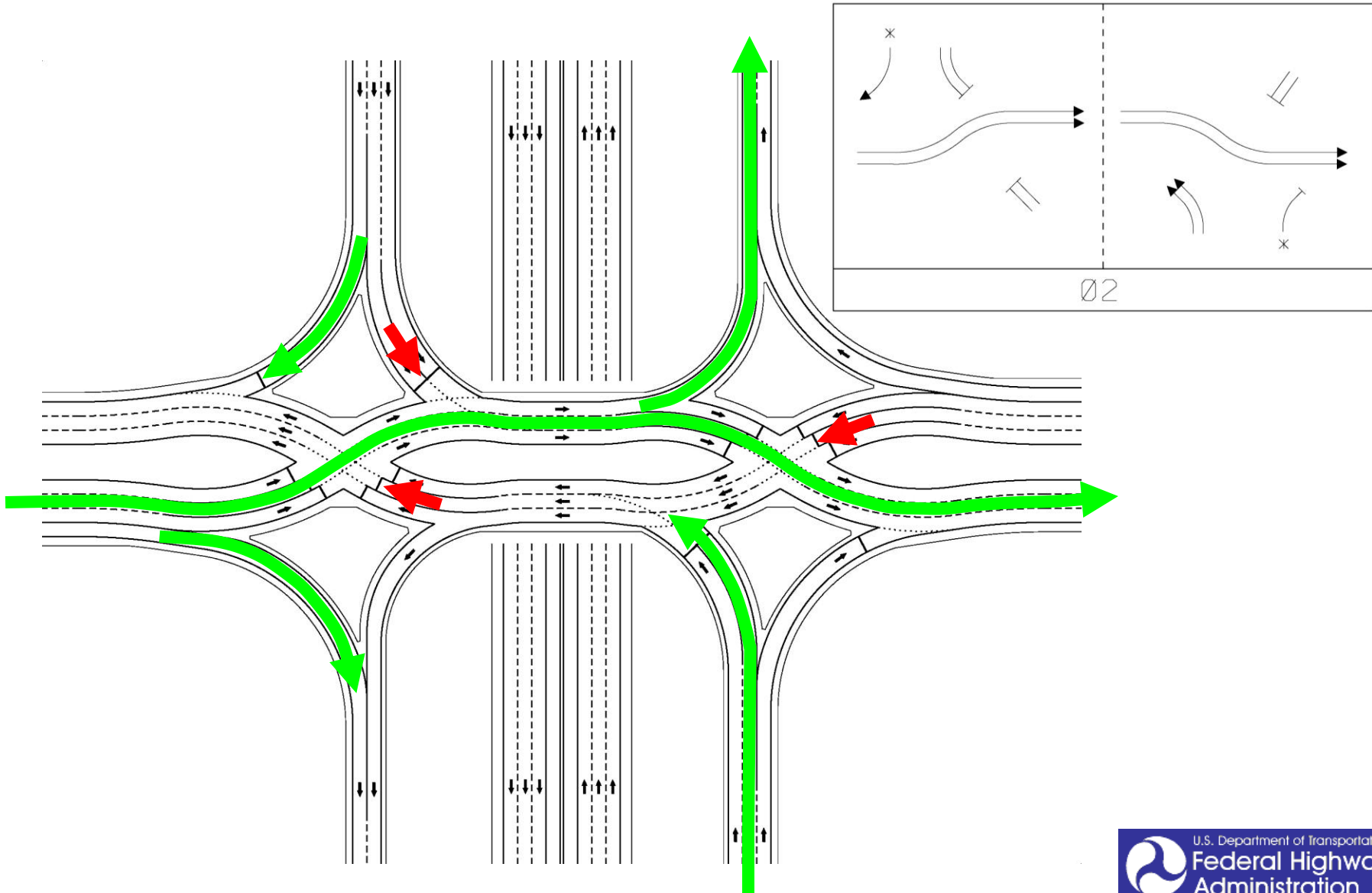


Why a Diverging Diamond?

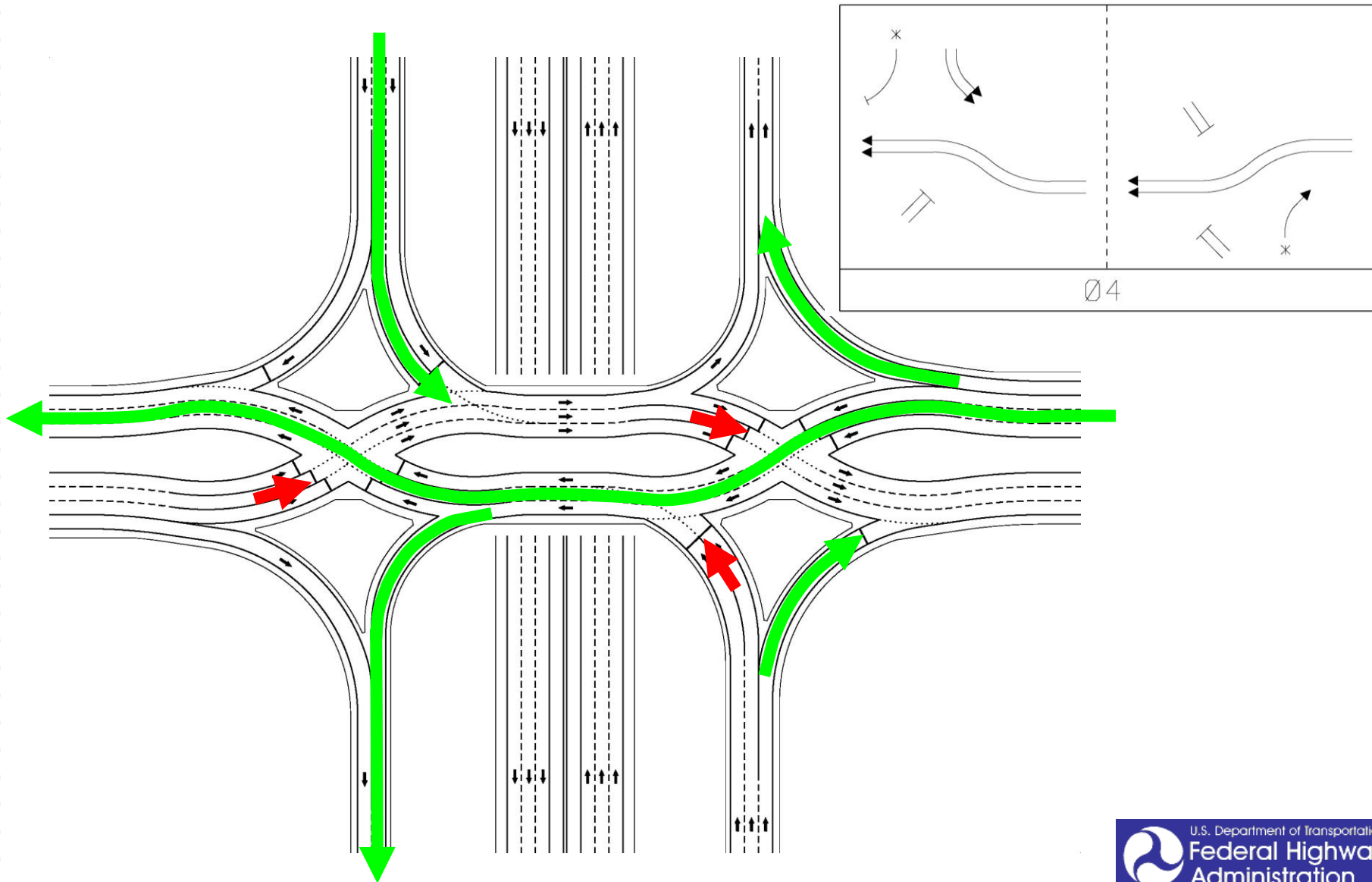
- ◆ Improved operational benefits with two phase signal operation since left-turn phase is eliminated



DDI Signal Phasing

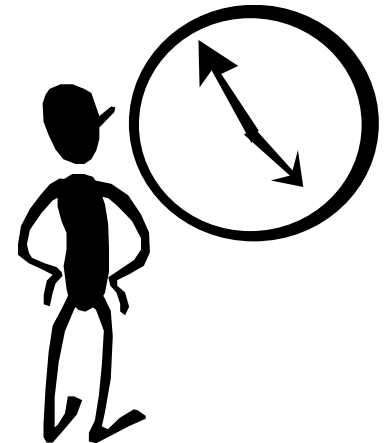


DDI Signal Phasing (Cont.)



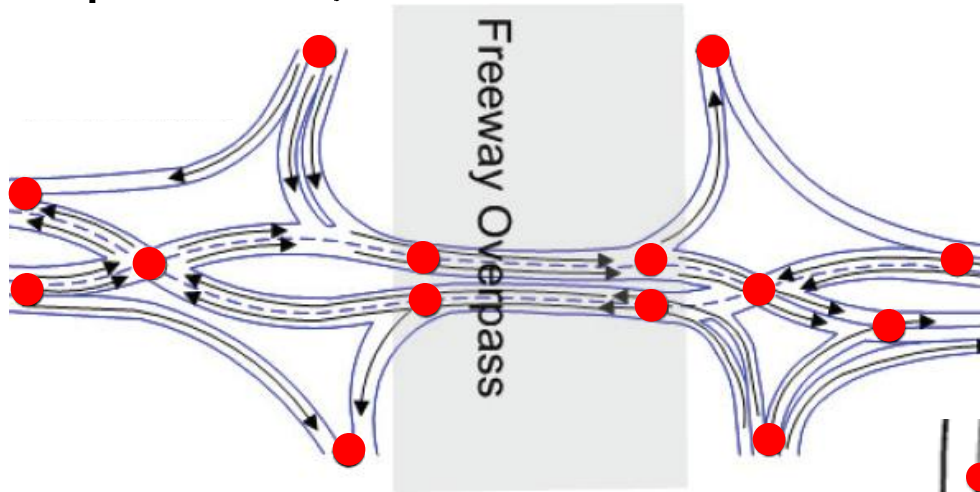
DDI Operational Benefits

- ◇ Research has shown that compared to a traditional diamond interchange, the DDI:
 - Reduces intersection delay by 15% – 60%
 - Increases throughput by 10% – 30%
 - Increases overall capacity by 15% – 25%
- ◇ A DDI accommodates heavy left-turn volumes onto ramps and from off-ramps
- ◇ A DDI accommodates moderate or unbalanced through volumes



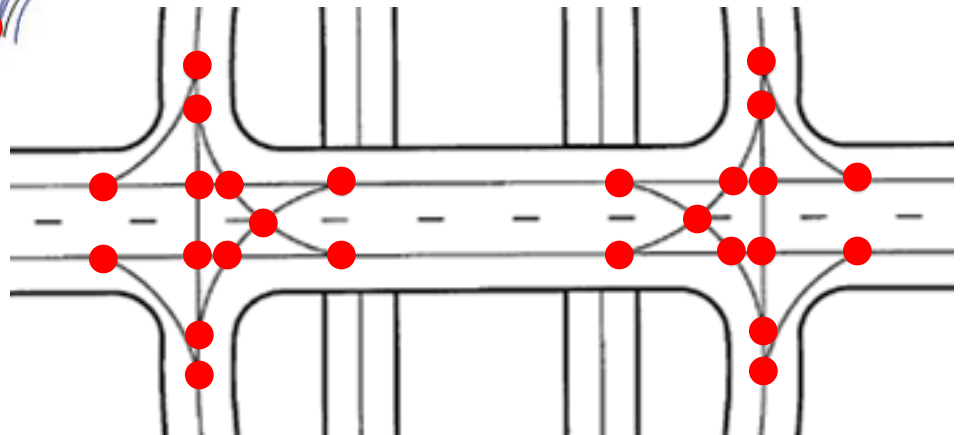
Why a Diverging Diamond?

- ◇ Theoretical safety benefit from reduction in potential vehicle-vehicle conflict points



◇DDI: 14 Conflict Points

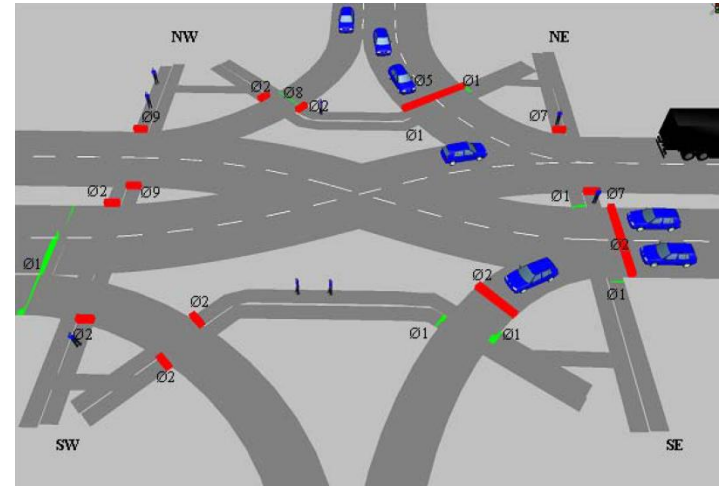
◇Traditional Diamond Interchange:
26 Conflict Points



◇Single Point Urban Interchange:
18 Conflict Points

Why a Diverging Diamond?

- ◇ Theoretical pedestrian safety improvement with multi-stage crossing as pedestrians only cross one direction of traffic at a time
- ◇ Curvature reduces vehicle speeds through intersections
- ◇ Potential for reduction of infrastructure costs through reduction of needed lanes and underpass/overpass bridge width



MoDOT Proposes DDI



- ◇ I-435 & Front Street
Kansas City, MO
 - Gateway to Northeast Industrial District



I-435 & Front Street Alternatives

TVDI vs. DDI

◇ Estimated Costs

	<u>TVDI</u>	<u>DDI</u>
Construction	\$ 6,866,000	\$ 4,918,000
Right of Way	\$ 3,868,000	\$ 1,445,000
Utilities	\$ 600,000	\$ 391,000
Total Costs	\$11,354,000	\$ 6,754,000



◇ Operations

- TVDI – 8 lanes, LOS C-F, Capacity @ 95%
- DDI – 4 lanes, LOS A-C, Capacity @ 60%

◇ Safety

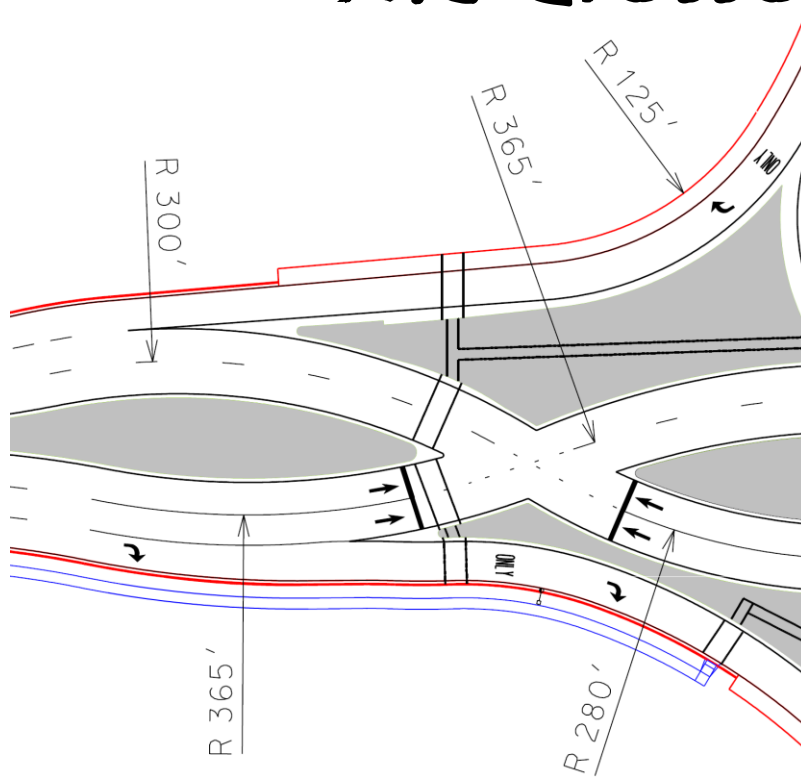
- TVDI – 45 Conflict Points
- DDI – 21 Conflict Points

Why Not Select a Diverging Diamond?

- ◇ The DDI is a new concept to drivers in the US
- ◇ The crossover maneuver is not intuitive because drivers travel on the opposite side of the road
- ◇ Concern that driver unfamiliarity will result in an increase in crashes

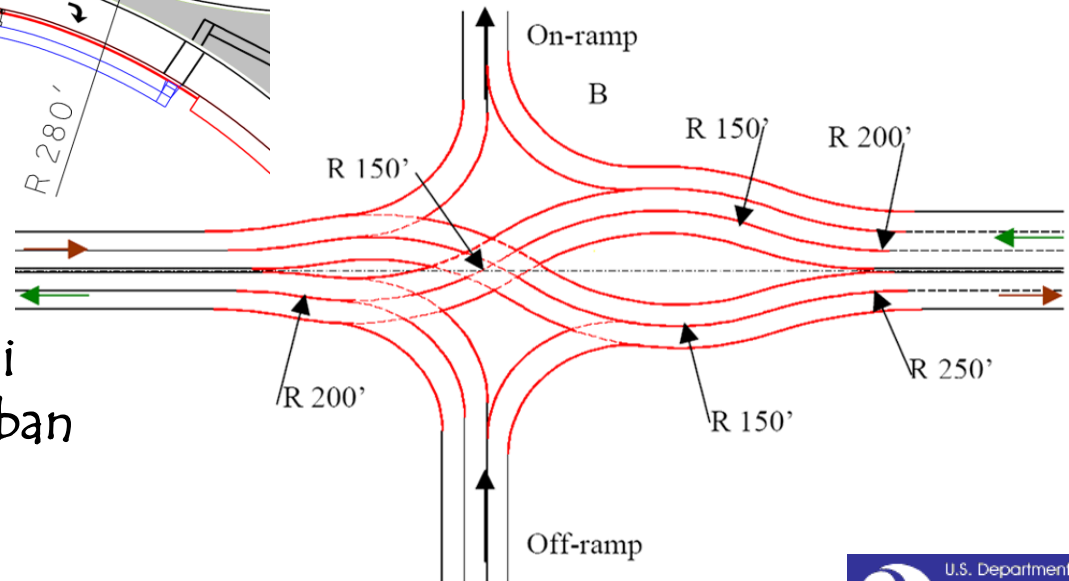


The Crossover Design



◇ Design of I-435 & Front Street DDI Crossover with larger radii to accommodate high truck/heavy vehicle %

◇ More typical design radii values expected for an urban DDI Crossover



FHWA Human Factors Driver Simulation Study

- ◇ Simulation of I-435 & Front Street DDI in Highway Driving Simulator at Turner-Fairbank Highway Research Center
- ◇ Three simulated interchanges – DDI, DDI (Mod), and Diamond
- ◇ 74 Drivers (Balance male/female & over/under 65)
- ◇ Results published in FHWA Tech Brief (www.tfhrc.gov)



I-435 & Front Street DDI Simulation



I-435 & Front Street DDI Simulation



I-435 & Front Street DDI Simulation



I-435 & Front Street DDI Simulation



Study MOEs and Results

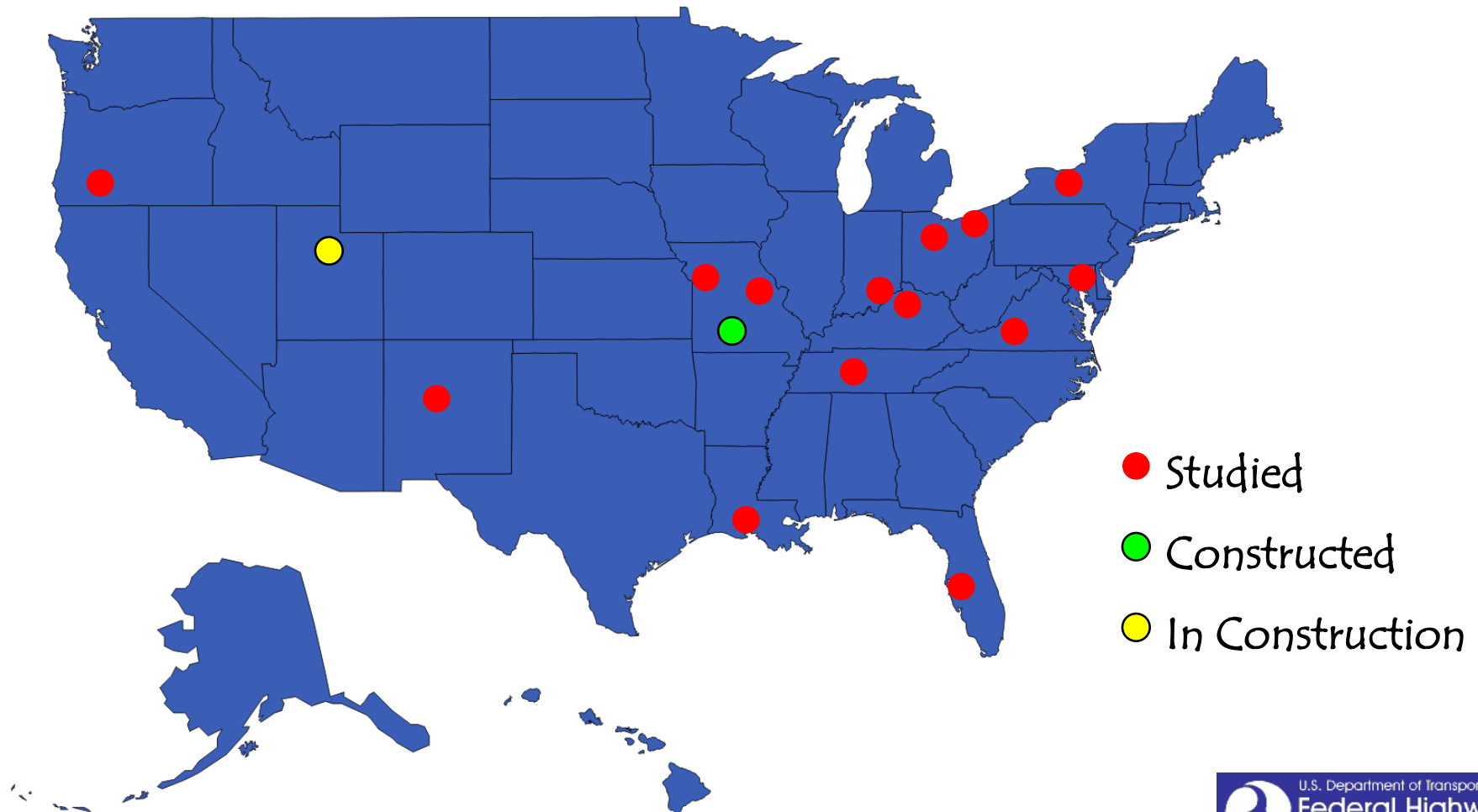
- ◇ Wrong-way Violations
 - No violations at crossover (1041 opportunities)
- ◇ Navigation Errors
 - Incorrect path on only 2.3% of opportunities
- ◇ Red-light Violations
 - Similar frequency although rare, but more violation opportunities with conventional diamond
- ◇ Speed @ Crossover
 - DDI – avg. 24 mph
 - Diamond – avg. 34 mph

DDI Conclusions/Recommendations

- ◇ The safety benefit combined with predicted operational benefits and reduced roadway width requirements make the DDI an attractive interchange alternative
- ◇ Simulation study suggests potential driver confusion not as significant of a concern and is mitigated with proper design (reverse curvature), signing, and markings

DDIs Under Consideration

◇ Status of DDIs in the following states:



I-590 & Winton in Rochester, NY



I-15 & American Fork in Sarasota Springs, UT



Under Construction – Project is 25% Complete

MoDOT & DDIs



- ◇ June 21, 2009 the first DDI in the United States opened at I-44 & Route 13 in Springfield, MO
- ◇ I-435 & Front Street in Kansas City, MO to be constructed soon
- ◇ Planned:
 - US 65 & Chestnut Expressway in Springfield, MO
 - US 60 & National Avenue in Springfield, MO
 - Botts Road & Route 150 in Kansas City, MO
 - I-270 & Dorsett Road in St. Louis County, MO

I-44 & Route 13 in Springfield, MO



inVISION Studios

I-44 & Route 13 in Springfield, MO



I-44 & Route 13 in Springfield, MO



I-44 & Route 13 in Springfield, MO



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